

An Indian-Australian research partnership

Project Title:	Blind Trajectory Calibration in MRI	
Project Number	IMURA0858	
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Research Clusters:

Research Themes:

Highlight which of the Academy's CLUSTERS this project will address? <i>(Please nominate JUST one. For more information, see www.iitbmonash.org)</i>		Highlight which of the Academy's Theme(s) this project will address? <i>(Feel free to nominate more than one. For more information, see www.iitbmonash.org)</i>	
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6	Bio, Stem Cells, Bio Chem, Pharma, Food	6	Biotechnology and Stem Cell Research
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8	HSS, Design, Management	8	Design

The research problem

MRI is a very popular modality for medical imaging. As per the underlying physics of the MR machine, it measures the Fourier transform of the diffusivity values of the underlying object at a set of user-specified frequencies where the i -th frequency is denoted as u_i . However due to hardware errors, the machine ends up measuring the Fourier transform at slightly different frequencies, where the i -th perturbed frequency is given by $u_i + d_i$. Note that in this scenario, the base frequency u_i is known, but the perturbation d_i is unknown. The reasons for these perturbations are gradient delays, i.e. the difference between the specified and actual start time of the MR machine.

Compressed sensing techniques have recently produced great success in reducing MRI acquisition time, because they allow for high fidelity signal reconstruction, even from undersampled measurements. These techniques primarily exploit the sparsity or compressibility of the underlying signals in their estimation. However these techniques require accurate specification of the sensing matrix, which in the case of MRI, consists of the Fourier matrix at the specified set of frequencies. The aforementioned frequency perturbations can cause serious degradation in reconstruction performance if ignored.

The aim of this project is to perform blind calibration, i.e. estimate both the underlying signal as well as the frequency perturbations in an alternating framework, in realistic settings in MR acquisition. More specifically, the project will seek to build upon the framework in [1] for MR reconstruction assuming a variety of different acquisition protocols and sampling schemes such as random Cartesian, radial, spiral, etc and compare it to methods from [2,3,4] which do not adopt a compressed sensing framework. The outcome of this project will provide a set of optimal MRI sampling trajectories which will greatly improve image reconstruction accuracy. We believe that this project could potentially support the design of lower cost MR scanners and improved image quality in the future.

References

1. E. Malhotra, H. Pandotra, A. Rajwade and K. Gurumoorthy, Dealing with frequency perturbations in compressive reconstructions with Fourier sensing matrices, Signal Processing (Elsevier), 2019. A pre-print is available here: <https://www.cse.iitb.ac.in/~ajitvr/publications.html>
2. A. Deshmane, M. Blaimer, F. Breuer, P. Jakob, J. Duerk, N. Seiberlich, and M. Griswold, "Self-calibrated trajectory estimation and signal correction method for robust radial imaging using GRAPPA operator gridding," Magnetic Resonance in Medicine, vol. 75, no. 2, pp. 883–896, 2016
3. A. Moussavi, M. Untenberger, M. Uecker, and J. Frahm, "Correction of gradient-induced phase errors in radial MRI," Magnetic Resonance in Medicine, vol. 71, no. 1, 2014.
4. J. D. Ianni and W. A. Grissom, "Trajectory auto-corrected image reconstruction," Magnetic resonance in medicine, vol. 76, no. 3, pp. 757–768, 2016.

Project aims

There are two main aims:

- Modelling of sources of trajectory error in MRI
- Development of algorithms for correction of trajectory errors along with underlying signal estimation in a compressive sensing framework

Expected outcomes

Models for expressing trajectory errors in MRI and algorithms to correct them along with estimation of the

signal. These tasks have implications for future development of low-cost MR scanners and improved image reconstruction quality.

How will the project address the Goals of the above Themes?

The project aims to further the state of the art in magnetic resonance imaging, a very important medical imaging modality.

Capabilities and Degrees Required

The student should have familiarity with and good understanding of basic techniques in image processing, signal processing and machine learning. The student must have the ability to program numerical algorithms using tools such as MATLAB, Numpy or C++ and possess mathematical maturity. An interest in signal processing and sparse representations is a plus. Knowledge of magnetic resonance imaging is a plus but not essential.

Potential Collaborators

Please visit the IITB website www.iitb.ac.in OR Monash Website www.monash.edu to highlight some potential collaborators that would be best suited for the area of research you are intending to float.

Select up to **(4)** keywords from the Academy's approved keyword list (**available at <http://www.iitbmonash.org/becoming-a-research-supervisor/>**) relating to this project to make it easier for the students to apply.

Compressed sensing, magnetic resonance imaging, trajectory correction